Multi-Model Ensemble Forecast of MJO







PI: Bin Wang, Department of Meteorology and IPRC, University of Hawaii

Co-PI: Duane Waliser, JIFRESSE, University of California, Los Angeles

Co-Is: Siegfried Schubert, GMAO, GSFC/NASA

Ben Kirtman, University of Miami

Bill Stern, GFDL/NOAA

Harry Hendon, Centre for Australian Weather and Climate Research

In-Sik Kang, Seoul National University

June-Yi Lee, Xiouhua Fu, IPRC, University of Hawaii

Collaborators at NCEP/NOAA

John Gottschalck, Arun Kumar, and Jae-Kyung E.

Schemm at CPC/NCEP

Stephen J. Lord and Augustin Vintzileos at EMC/NCEP

Year 1: August 1, 2010 - July 31, 2011

Year 2: August 1, 2011 – July 31, 2012

Year 3: August 1, 2012 – July 31, 2013

Major Tasks



Construct a well-designed and coordinated MJO hindcast experiment (ISVHE)



Assess the predictability and prediction skill of the MJO and related N. American impacts



Examine the sensitivity of the prediction skill to initialization and parameterization with the multi-model framework



Develop an MME technique suitable for MJO prediction and assess improvements in MJO prediction skill



Collaborate with MJO forecast activity at CPC to deliver an MME methodology suitable for operational MME implementation at NCEP



Using historical data combined with MME, develop composite response of the N. American weather/climate to the life-cycle of the MJO.

Results and Accomplishments during Year 1

- 1 ISV hindcast experiment (ISVHE)
- Impact of initial condition on ISV prediction
- Bimodal representation of the Tropical ISO
- MJO modulation on 2009/10 winter US snowstorms
- A metrics for boreal summer ISO and teleconnection



ISVHE Objectives



- ◆ Better understand physical basis for intraseasonal prediction.
- ◆ Estimate potential and practical predictability of ISO in a multimodel frame work.
- ◆ Developing optimal strategies for multi-model ensemble (MME) ISO prediction system, including effective initialization schemes and quantification of the MME's ISO prediction skills with forecast metrics under operational conditions.
- ◆ Identify model deficiencies and suggest ways to improve models' convective and other physical parameterizations.
- ◆ Revealing new physical mechanisms associated with ISV that cannot be obtained from analyses of a single model.
- ◆ Study ISO's modulation of extreme hydrological events and its contribution to seasonal and interannual climate variation.

Experimental Designs

Control Run

Free coupled runs with AOGCMs or AGCM simulation for at least 20 years

Daily or 6hourly output

ISV Hindcast EXP

initiated every 10 for at least 45 days with more than 6 ensemble members from 1989 to 2008

Daily or 6-hourly output

YOTC EXP

Additional EXP for YoTC period from May 2008 to Sep 2009

6-hourly output

1

CliPAS/ISVHE Participations

Institution	Participants					
ABOM, Australia	Harry Hendon, Oscar Alves					
CMCC, Italy	Antonio Navarra, Annalisa Cherichi, Andrea Alessandri					
CWB, Taiwan	Mong-Ming Lu					
ECMWF, EU	Franco Molteni, Frederic Vitart					
GFDL, USA	Bill Stern					
JMA, Japan	Kiyotoshi Takahashi					
MRD/EC, Canada	Gilbert Brunet, Hai Lin					
NASA/GMAO, USA	S. Schubert					
NCEP/CPC	Arun Kumar, Jae-Kyung E. Schemm					
PNU, Korea	Kyung-Hwan Seo					
SNU, Korea	In-Sik Kang					
UH/IPRC, USA	Bin Wang, Xiouhua Fu, June-Yi Lee					



ISVHE MODELS



Intraseasonal Variability Hindcast Experiment

The ISVHE is a coordinated multi-institutional ISV hindcast experiment supported by APCC, NOAA CTB, CLIVAR/AAMP & MJO WG, NOAA CTB, and AMY.



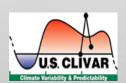
http://iprc.soest.hawaii.edu/users/jylee/clipas.htm

Supporters







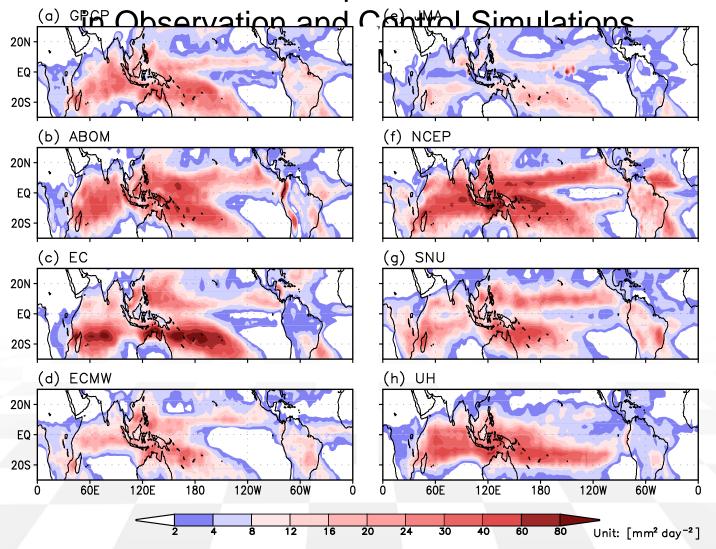






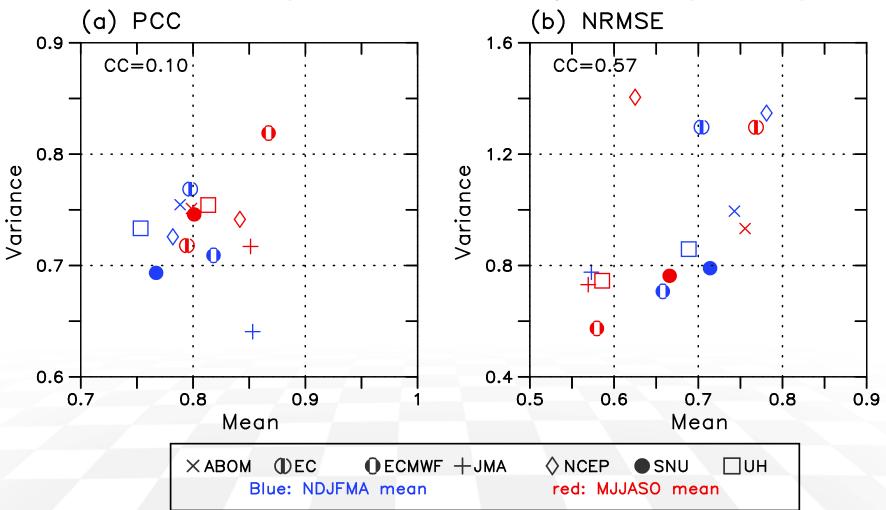
Evaluation of Control Runs

Variance of 20-100-day Bandpass Filtered Precipitation



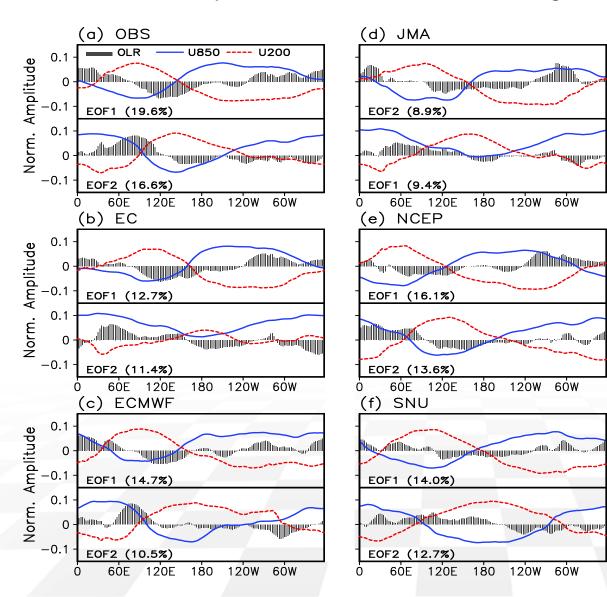
Evaluation on Control Runs

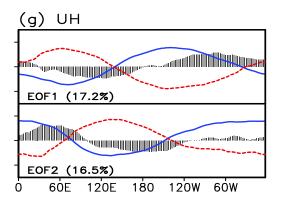
Pattern Correlation Coefficient and Normalized Root Mean Square Error for Mean Precipitation and 20-100-day Variance (30S-30N)



Evaluation on Control Runs

20-100-Day U850, U200 and OLR along the equator (15°S-15°N)

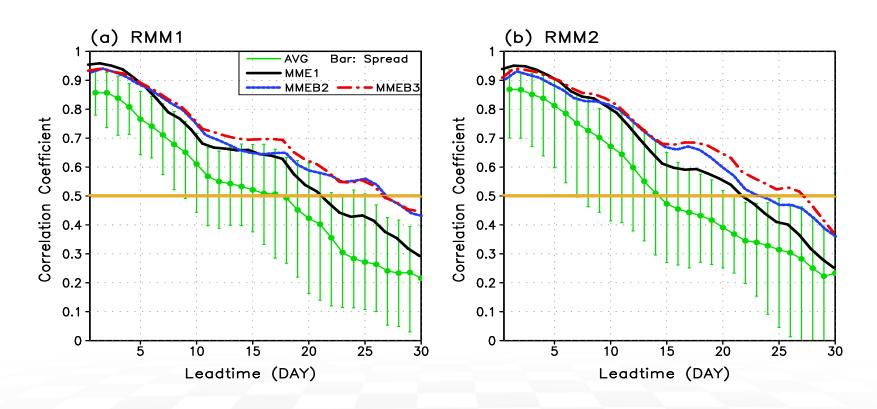




The first two MV-EOF modes of 20-100-day 850- and 200-hPa zonal wind and OLR along the equator (15°S-15°N) obtained from obs and control simulations. The percentage variance explained by each mode is shown in the lower of each panel. (Wheeler and Hendon 2004)

The MME and Individual Model Skills for MJO

Preliminary results from 6 models



Common Period: 1989-2008

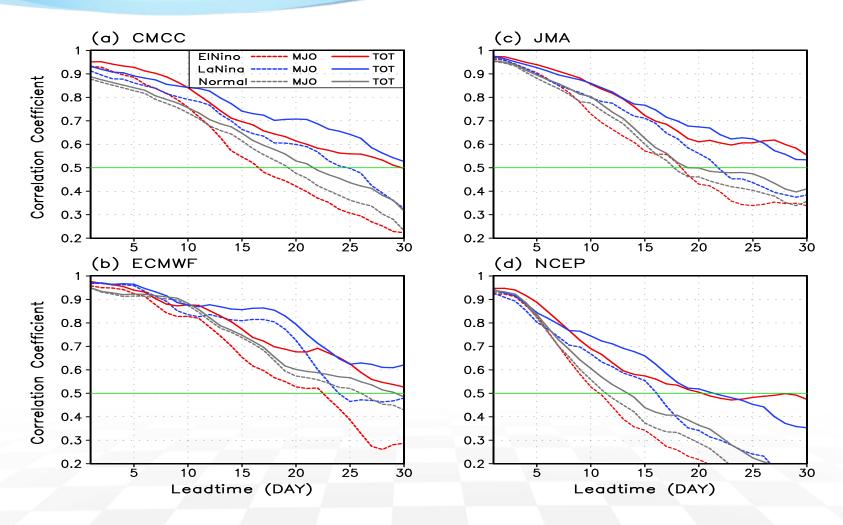
Initial Condition: 1st day of each month from Oct to March

MME1: Simple composite with all models

MMEB2: Simple composite using the best two models MMEB3: Simple composite using the best three models



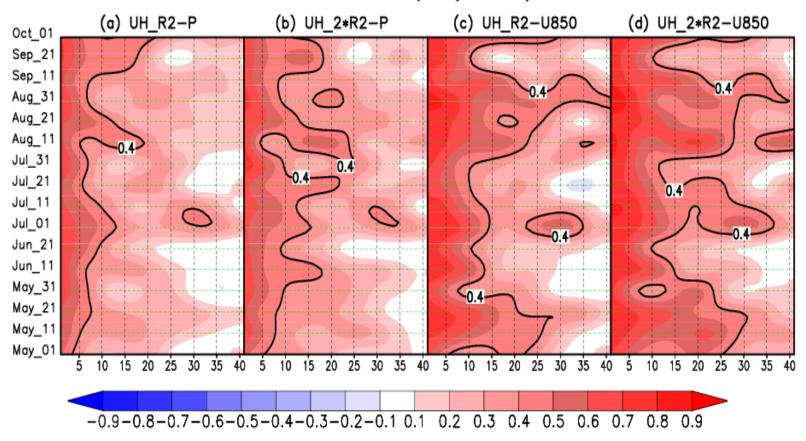
MJO Skill depends on ENSO phase



- ✓ Taking into account IAV anomaly, the practical TCC skill for the RMM1 and 2 extends about 5 to
 10 days depends on model. The improvement is remarkable for the RMM1.
- ✓ The skill in La Nina years is better than El Nino years in most models.

Impact of Initial Condition on ISO Prediction

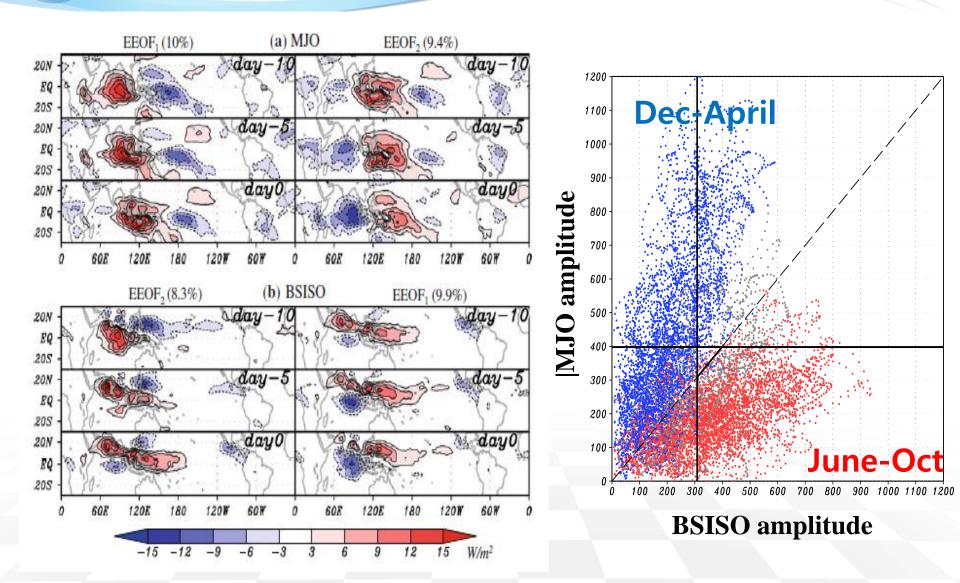
ACC of 30-90-day Filtered Forecasts in 2008 Summer Over Global Tropics (30S-30N)



(a) skills of filtered rainfall initialized with the original NCEP_R2; (b) with doubled ISO signals in the NCEP_R2; (c) skills of filtered U850 initialized with the original NCEP_R2; (d) with doubled ISO signals in the NCEP_R2.



Bimodal Representation of the Tropical ISO



Spatial-temporal pattern of OLR anomaly associated with ISO during (a) boreal winter (DJF, referred to as MJO mode) and (b) boreal summer (JJA, referred to as BSISO mode) by EEOF analysis.

4

MJO Modulation on 2009/10 Winter Snowstorm in the US

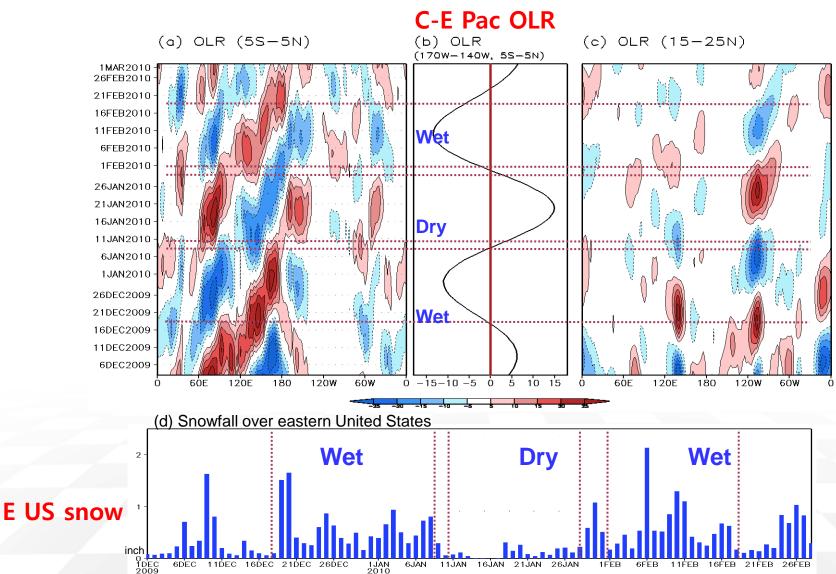
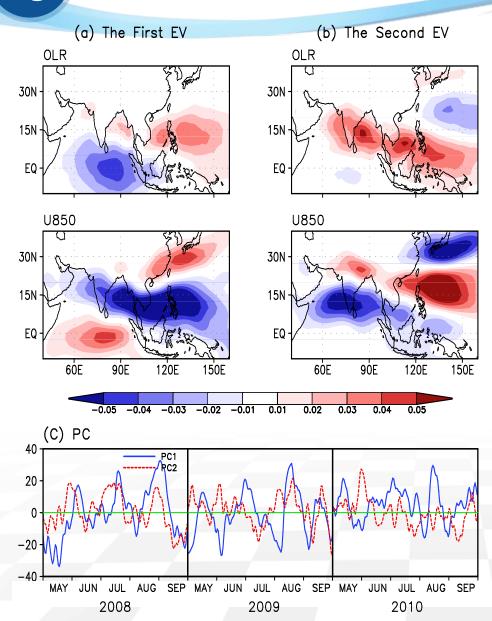
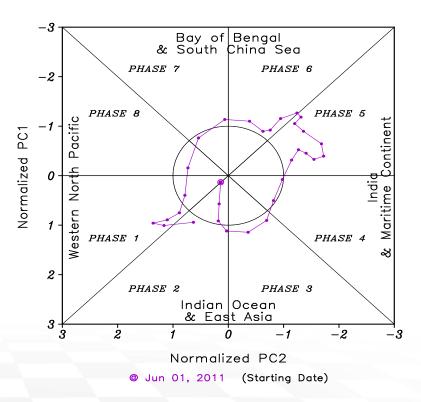


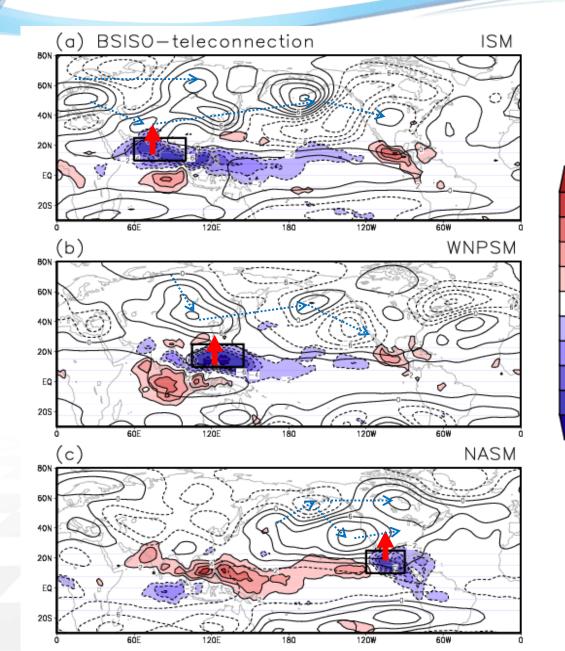
Fig: Time-Longitude Hovmöller diagrams of intraseasonal (contour) and total (shading) OLR over (a) tropics (5°S–5°N) and (c) subtropics (15°–25°N), (b) central tropical Pacific (170-140W, 5S-5N) from 1 December 2009 to 28 February 2010.

A Metrics for Boreal summer monsoon ISO





BSISO Teleconnection



Regressed GPH200 (Contour) and OLR (shading) according to ISM, WNPSM, and NASM index

Blue and red arrows indicate the propagation of the wave activity flux.

10

Highlights of Accomplishment

- The ISVHE has been accomplished to better understand the physical basis for prediction and determine predictability of ISO.
- Ten models' hindcast for ISO have been collected.
- Using the best three models' MME, ACC skill for RMM1 and RMM2 reaches 0.5 at 27-day forecast lead.
- An improve the initial conditions extends skillful rainfall prediction by 2-4 days and U850 prediction by 5-10 days.
- The Bimodal representation of ISO accounts for more fractional variance than without considering seasonality.
- During the winter of 2009/10, a number of record-breaking snowfall events registered in the eastern US are shown to have been modulated by pulsation of tropical MJO through atmospheric teleconnection.
- A new MISO index was designed to represent larger fractional variance over the Asian monsoon region, and the reconstructed life cycle captures more realistic features of the observed phenomenon.
- The robust intraseasonal coupled modes between the tropics and extratropics during boreal summer is being investigated.

Publications from the Project

Fu, X. H., B. Wang, J.-Y. Lee, W. Q. Wang, and L. Gao, 2011: Sensitivity of dynamical intra-seasonal prediction skills to different initial conditions. Monthly Weather Review, In press

Kkiuchi, K., B. Wang, and Y. Kajikawa, 2011: Bimodal representation of the Tropical intraseasonal osciilation. Climate Dynamics, in revision.

Mon, J.-Y., B. Wang, and K.-J. Ha, 2011: Modulation on 2009/10 winter snowstorms in the United States. Journal of Climate, in revision.

Lee, J.-Y., B. Wang, M. Wheeler et al. 2011: A metrics for Boreal summer monsoon intraseasonal oscillation (MISO). In preparation

Moon, J.-Y., B. Wang, K. Kikuchi, J.-Y. Lee, and K.-J. Ha, 2011: Dominant modes in the boreal summer intraseasonal oscillation teleconnection. In preparation

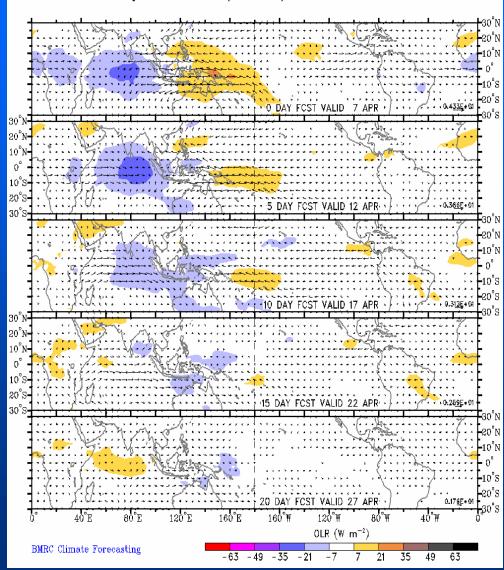
Thank you for questions and comments



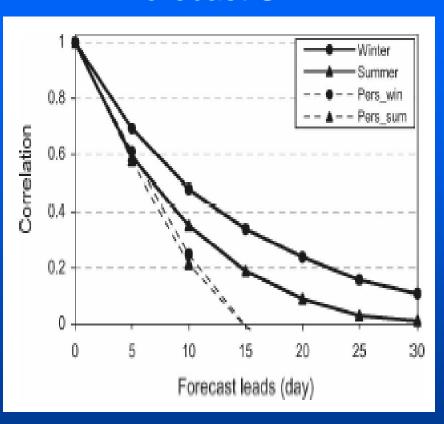
Statistical Predictions – WH Lagged Linear Regression



Shading for OLR anomalies (scale below). Vectors for 850-hPa wind



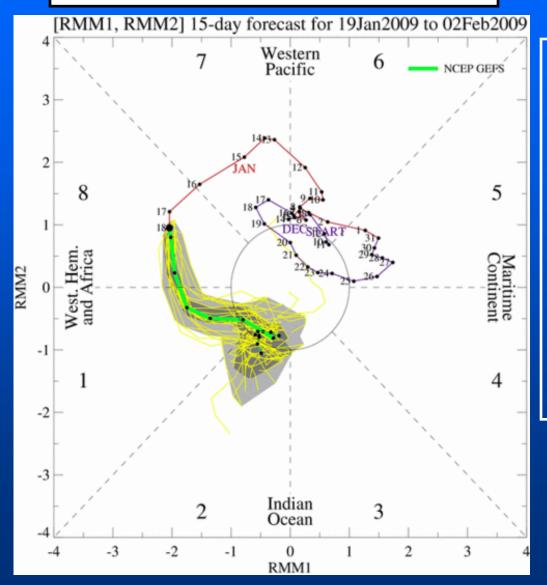
Forecast Skill



From Gottschalck

<u>Dynamical Predictions – GEFS</u>

<u>Yellow Lines</u> – 20 Individual Members <u>Green Line</u> – Ensemble Mean



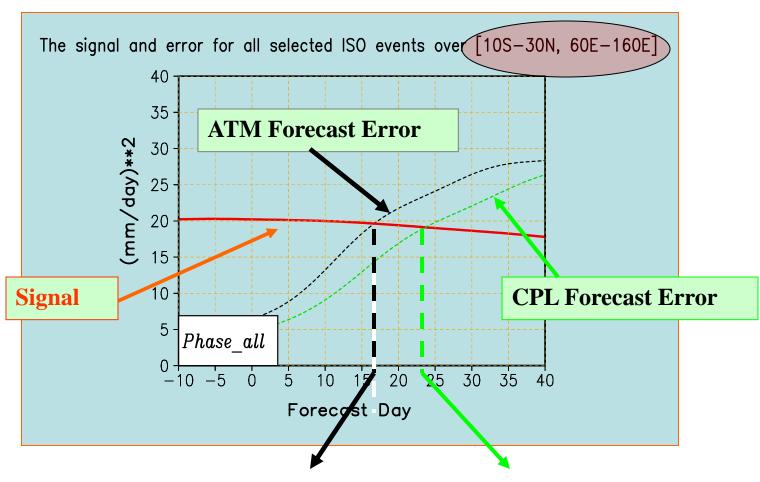
RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading:
90% of members

dark gray shading: 50% of forecasts



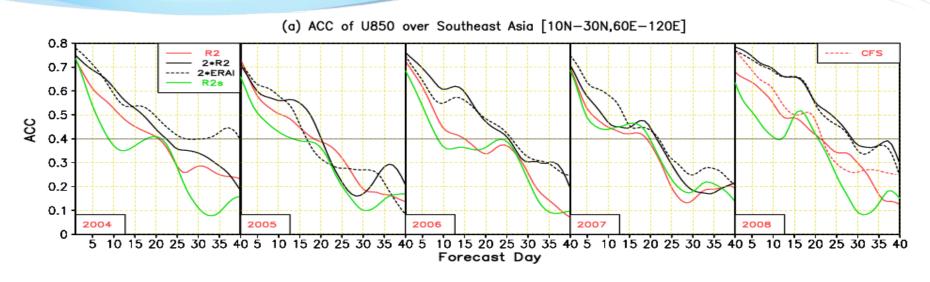
Air-Sea Coupling Extends the Predictability of Monsoon Intraseasonal Oscillation

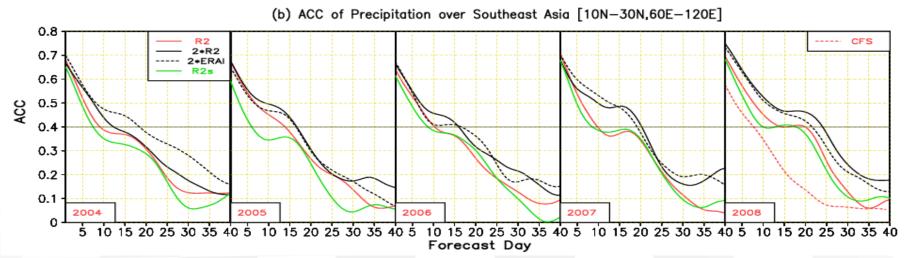


[ATM: 17 days; CPL: 24 days]

Fu et al. (2007)

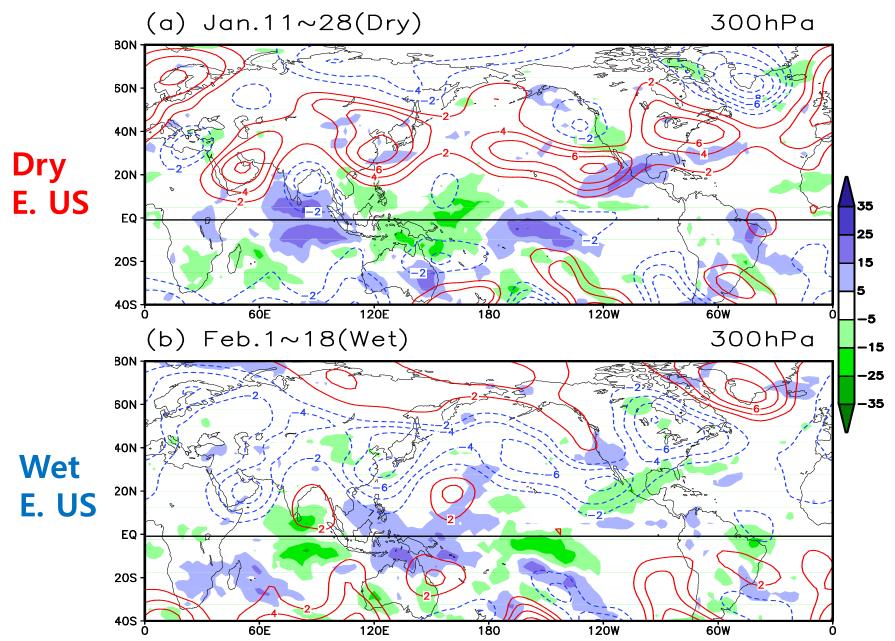
Impact of Initial Condition on ISO Prediction





Forecast by UH_HCM in 2004-2008 summer seasons initialized with the original NCEP_R2 (red solid), spatial-smoothed NCEP_R2 (green solid lines), doubled ISO signals in the NCEP_R2 (black solid), and doubled ISO signals in the ERA_Interim (dash solid lines).

MJO-US Teleconnection: OLR and H300



ISVHE Models



One-Tier System

	Model	Control Run	ISO Hindcast			
	Model		Period	Ens No	Initial Condition	
ABOM	POAMA 1.5 (ACOM2+BAM3)	CMIP (100yrs)	1980-2006	10	The first day of every month	
СМСС	CMCC (ECHAM5+OPA8.2)	CMIP (20yrs)	1989-2008	5	Every 10 days	
ECMWF	ECMWF (IFS+HOPE)	CMIP(11yrs)	1989-2008	15	The first day of every month	
GFDL	CM2 (AM2/LM2+MOM4)	CMIP (50yrs)	1982-2008	10	The first day of every month	
JMA	JMA CGCM	CMIP (20yrs)	1989-2008	6	Every 15 days	
NCEP/CPC	CFS (GFS+MOM3)	CMIP 100yrs	1981-2008	5	Every 10 days	
PNU	CFS with RAS scheme	CMIP (13yrs)	1981-2008	3	The first day of each month	
SNU	SNU CM (SNUAGCM+MOM3)	CMIP (20yrs)	1989-2008	1	Every 10 days	
UH/IPRC	UH HCM	CMIP (20yrs)	1994-2008	6	The first day of every month	

Two-Tier System

	Model	Control		ISO Hindcast		
		Run	Period	Ens No	Initial Condition	
CWB	CWB AGCM	AMIP (25yrs)	1981-2005	10	Every 10 days	
MRD/EC	GEM	AMIP (21yrs)	1985-2008	10	Every 10 days	

Impact of Initial Condition on ISO Prediction

Averaged Prediction Skills of 2008 Summer Monsoon over Global Tropics (30°S-30°N)

